CLAIMS

I claim:

1. An armor comprising a metallic material that absorbs energy from a projectile impacting the armor, wherein said material is selected from at least one of a metallic material that undergoes a reversible phase change upon absorbing energy and a metallic material that exhibits an elastic strain deformation of at least 5%.

2. The armor of claim 1, wherein the armor comprises a plurality of layers, including a first layer comprising said material.

3. The armor of claim 2, wherein said first layer consists of said material.

4. The armor of claim 1, wherein said material undergoes a reversible endothermic phase change when heated to a predetermined temperature.

5. The armor of claim 4, wherein said predetermined temperature is at least -50°C and is no greater than 200°C.

6. The armor of claim 5, wherein said material is selected from the group consisting of nickel-titanium alloys, copper-zinc alloys, and copper-aluminum-nickel-manganese alloys.

7. The armor of claim 6, wherein said material is an alloy consisting essentially of 45 up to 55 atomic percent nickel, 45 up to 55 atomic percent titanium, and incidental impurities.

8. The armor of claim 7, wherein said material is Nitinol.

9. The armor of claim 1, wherein the armor comprises a first plate including a first energy absorbing layer and a second energy absorbing layer, said first energy absorbing layer comprising a material that absorbs energy by a reversible phase change and said second energy absorbing layer comprising a material that absorbs energy by elastic deformation and exhibits elastic strain of at least 5%.

10. The armor of claim 2, wherein said first layer is a first plate, the armor further comprising a second plate, said second plate comprising a material that differs from said first plate.

11. The armor of claim 10, wherein said second plate comprises a material selected from the group consisting of titanium, gamma phase titanium-aluminum, α titanium alloy, β titanium alloy, and $\alpha\beta$ titanium alloy.

12. The armor of claim 11, wherein said α titanium alloy is at least one of grades 1-4 CPTi.

13. The armor of claim 11, wherein said $\alpha\beta$ titanium alloy is Ti(6-4).

14. The armor of claim 11, wherein said β titanium alloy is at least one of Ti(10-2-3) and Ti(15-3-3-3).

15. The armor of claim 10, wherein said second plate is contiguous with said first plate.

16. The armor of claim 15, wherein said second plate is diffusion bonded to said first plate.

17. The armor of claim 10, further comprising a third plate disposed opposite said second plate and comprised of a material that differs from said first plate.

18. The armor of claim 17, wherein said third plate is a material selected from the group consisting of titanium, gamma phase titanium-aluminum, α titanium alloy, β titanium alloy, and $\alpha\beta$ titanium alloy.

19. The armor of claim 2, wherein said first layer is a first plate that comprises an alloy consisting essentially of 45 up to 55 atomic percent nickel, 45 up to 55 atomic percent titanium, and incidental impurities, the armor further comprising a second plate including a material selected from the group consisting of titanium, gamma phase titanium-aluminum, α titanium alloy, β titanium alloy, and $\alpha\beta$ titanium alloy.

20. The armor of claim 19, wherein said first plate is contiguous with said second plate.

21. The armor of claim 19, further comprising a third plate disposed opposite said second plate and comprising a material that differs from said first plate.

22. The armor of claim 21 wherein said third plate comprises a material selected from the group consisting of titanium, gamma phase titanium-aluminum, α titanium alloy, β titanium alloy, and $\alpha\beta$ titanium alloy.

23. The armor of claim 21 wherein said first plate is contiguous with said third plate.

24. A method of making an armor plate, the method comprising:

providing a first plate comprising at least one energy absorbing layer comprising a metallic material that absorbs energy from an object when the object impacts the armor plate by at least one mechanism selected from a reversible phase change and an elastic strain deformation of at least 5%;

providing a second plate of a material differing from the first plate;

contacting the first plate and the second plate; and

bonding the first plate to the second plate and, optionally, reducing a thickness dimension of the first plate and the second plate.

25. The method of claim 24 wherein said first plate comprises a first energy absorbing layer and a second energy absorbing layer, wherein one of said first energy absorbing layer and said second energy absorbing layer comprises a material that absorbs energy by a reversible phase change and the other of said first energy absorbing layer and said second energy absorbing layer comprises a material that absorbs energy by an elastic strain deformation of at least 5%, and wherein said first energy absorbing layer is contacted to said second energy absorbing layer.

26. The method of claim 24 wherein contacting surfaces of the first plate and the second plate are cleaned before contacting the first plate and the second plate.

27. The method of claim 24, wherein the first plate is of a material that undergoes a reversible endothermic phase change when heated to a predetermined temperature.

28. The method of claim 27, wherein the predetermined temperature is at least -50°C and is no greater than 200°C.

29. The method of claim 28, wherein the first plate is of a material selected from the group consisting of nickel-titanium alloys, copper-zinc alloys, and copper-aluminum-nickel-manganese alloys.

30. The method of claim 29, wherein the first plate is of an alloy consisting essentially of 45 up to 55 atomic percent nickel, 45 up to 55 atomic percent titanium, and incidental impurities.

31. The method of claim 24, wherein the second plate comprises a material selected from the group consisting of titanium, gamma phase titanium-aluminum, α titanium alloy, β titanium alloy, and $\alpha\beta$ titanium alloy.

32. The armor plate of claim 31 wherein said α titanium alloy is at least one of grades 1-4 CPTi.

33. The armor plate of claim 31 wherein said $\alpha\beta$ titanium alloy is Ti(6-4).

34. The armor plate of claim 31 wherein said α titanium alloy is at least one of Ti(10-2-3) and Ti (15-3-3-3).

35. The method of claim 24, wherein bonding the first plate and the second plate comprises:

heating the first plate and second plate; and

applying bonding pressure to the first plate and the second plate to provide a metallurgical bond.

36. The method of claim 35, wherein applying bonding pressure to the first plate and the second plate comprises rolling the first plate and the second plate.

37. The method of claim 24, further comprising:

providing a third plate of a material differing from the first plate;

disposing the third plate opposite the second plate;

contacting the third plate and the first plate; and

bonding the first plate to the third plate.

38. The method of claim 37 wherein contacting surfaces of the first plate and the third plate are cleaned before contacting the first plate and the third plate.

39. The method of claim 37, wherein the third plate comprises a material selected from the group consisting of titanium, gamma phase titanium-aluminum, α titanium alloy, β titanium alloy, and $\alpha\beta$ titanium alloy.

40. The armor plate of claim 39 wherein said α titanium alloy is at least one of grades 1-4 CPTi.

41. The armor plate of claim 39 wherein said $\alpha\beta$ titanium alloy comprises Ti(6-4).

42. The armor plate of claim 39 wherein said α titanium alloy comprises at least one of Ti(10-2-3) and Ti (15-3-3-3).

43. The method of claim 37, wherein bonding the first plate and the third plate comprises:

heating the first plate and third plate; and

applying bonding pressure to the first plate and the third plate to provide a metallurgical bond.

44. The method of claim 43, wherein applying bonding pressure to the first plate and the third plate comprises rolling the first plate and the third plate.

45. An article of manufacture including an armor comprising a metallic material that is selected from a metallic material that undergoes a reversible phase change upon absorbing energy and a metallic material that exhibits an elastic strain deformation of at least 5%.

46. The article of manufacture of claim 45, wherein the article is an armored vehicle.

47. A method of absorbing energy from a projectile comprising forming an armor comprised of a metallic material that absorbs energy from the projectile, wherein said material is selected from at least one of a material that undergoes a reversible phase change upon absorbing energy and a metallic material that exhibits an elastic strain deformation of at least 5%.

48. The method of claim 47, wherein the armor comprises a plurality of layers, including a first layer comprising said material.

49. The method of claim 47, wherein said material is selected from the group consisting of nickel-titanium alloys, copper-zinc alloys, and copper-aluminum-nickel-manganese alloys.